Improving Regional Planning of Wetland Ecosystem Restoration and Management in Southern California

Southern California Wetland Recovery Project Science Panel Recommendations

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EXECUTIVE SUMMARY

The Science Advisory Panel (SAP) was established by the Southern California Wetland Recovery Project (WRP) Governing Board to ensure that the best available science is incorporated into the decision-making processes of the WRP, and to advise the board on regional goals, objectives, project criteria, and priorities. This document is the first in a series of SAP position papers making specific recommendations to the WRP on improving regional planning of wetland ecosystem restoration and management in Southern California.

The recently published WRP Regional Strategy lays out a long-term vision, programmatic goals, and implementation strategies to guide WRP efforts. **To ensure these goals are achieved, the SAP recommends implementing three major initiatives designed to better support regional planning:**

1. **Establish quantifiable recovery objectives;**
2. **Develop decision support tools to aid in prioritizing preservation and restoration activities; and**
3. **Implement a regional monitoring program to measure the progress towards objectives.**

Quantifiable recovery objectives differ from the Regional Strategy goals in that they specify the elements of ecosystem structure and function that must be maintained or restored to achieve "recovery." These scientific criteria form the basis by which to evaluate WRP progress towards recovery. The also constitute the ecological criteria that should be considered in prioritization of WRP preservation and restoration projects. **There are five recommended quantifiable recovery objectives:**

1. **Maintain existing and increase wetland acreage;**
2. **Recover habitat diversity to reflect historic distribution to the extent possible;**
3. **Restore physical processes;**
4. **Recover biological structure and function; and**
5. **Recover landscape elements of ecosystem structure**.

This paper provides a detailed explanation and a rationale for why each objective is important.

Once WRP programmatic goals and quantifiable recovery objectives have been established, the next step is to use them to guide WRP preservation and restoration activities, based on a set of clearly defined priorities. In determining the priority of a project for funding, it is important that its merit to the ecological recovery of the region be clearly established, along with considerations such as technical feasibility and cost. The **SAP recommends that the WRP develop decision support tools to help prioritize the funding of preservation and restoration activities based on the ecological criteria outlined in the quantifiable recovery objectives.** The WRP should undertake two types of decision support projects: 1) establishment of habitat acreage goals, and 2) prioritization of riparian corridor preservation and restoration in coastal watersheds.

Establishment of habitat acreage goals is a means of prioritizing funding to restore the habitat types that have experienced the greatest loss. The targets can be developed by: 1) comparing historical versus present day wetland acreage by habitat type, and 2) developing the habitat acreage requirements of indicator and endangered species using monitoring data and best professional judgment. Implementation of a habitat goals project depends on the development of data sources for this assessment. **The SAP recommends updating the historical and present-day inventories by habitat type, and cataloging monitoring data used to develop habitat requirements for wetland species.** The SAP will provide specific recommendations on establishing targets once the availability and quality of these data are documented.

Given the recent expansion of recovery activities into freshwater wetlands and adjacent riparian habitat, the WRP must develop a coherent strategy for allocating funding to projects in the 10,000 sq km of southern California coastal watersheds. This strategy must be based in part on an assessment of the merits of the project from an ecological perspective. **The SAP recommends that the WRP pursue the development of a decision support tool that will aid in identifying high priority riparian areas for preservation and restoration.** This tool could be used by the WRP Managers group to guide the annual project selection, and by the WRP County Task Forces as a preliminary screening tool to develop priorities for the watershed management planning process.

The SAP has begun to work with the NOAA Coastal Services Center (CSC), WRP Managers group, and Task Forces to adapt the Spatial Wetlands Assessment for Management and Planning (SWAMP) model for WRP use. SWAMP, a NOAA CSC product, is a GIS model used to examine the ecological significance of a wetland to its watershed by assessing contributions it makes to habitat support, water quality, and hydrology. NOAA CSC has agreed to provide the technical expertise to adapt SWAMP for southern California. In developing SWAMP, the WRP will engage in a discussion of the ecological attributes of riparian areas that merit preservation and restoration, and relative importance of each. **The SAP advocates that the WRP support the implementation of the SWAMP decision support tool by:**

1. **Reviewing SWAMP assessment framework currently under development, and**
2. **Developing data layers to support the SWAMP assessment (details on these data layers are given in Section IV.B).**

By setting regional goals and quantifiable recovery objectives, the WRP has clearly defined goals for the program, and the elements of wetland structure and function that must be restored for ecosystem recovery. The next logical step is to implement a monitoring program that assesses baseline conditions, measures recovery progress, and evaluates the effect of anthropogenic stressors constraining recovery. This program would have many other benefits. Among them, it would provide an integrated and cost-effective regional approach to addressing the management information needs of WRP partners. It would streamline reporting of monitoring data, making them more accessible for routine scientific evaluation of restoration and management techniques. The monitoring program could also serve to verify the effectiveness of wetland regulatory and management policy. **Recommendations for the implementation of this program include the need to:**

1. **Update present-day and historical inventories of wetland ecosystems,**

2. **Develop a regional survey of resource condition and stressors,**
3. **Develop a program to monitor success of restoration projects;**
4. **Improve coordination of project-specific monitoring, and**
5. **Develop the administrative infrastructure to support this program.**

The SAP envisions that this position paper will serve to initiate a lively dialogue among WRP partners on ways to improve regional planning, and build support and momentum for the implementation of the three recommended initiatives described in this document. We look forward to feedback from the WRP partners on the contents of this paper. Future position papers will focus specifically on detailing specific assessment frameworks and detailed implementation plans for regional monitoring, habitat acreage goals, and the SWAMP decision support tool.

CHAPTER I: INTRODUCTION

A. Background

The southern California coastal province is a distinct region that extends from Point Conception in Santa Barbara County to Punta Banda, south of Ensenada, Baja Mexico, and includes all watersheds that drain to the Pacific Ocean (Fig. 1). The physical features, climate, and hydrology of this biogeographic province have produced an unusual set of hydrogeomorphic conditions and a diversity of plants and animals that sharply distinguish the region from any other in North America. Southern California's embayments and wetlands are among the most diverse, productive and densely populated habitats on the Pacific coast.

Figure 1. Map of southern California showing location of coastal watersheds where Southern California Wetland Recovery Project activities occur (map courtesy of Lori Sutter, NOAA)

Southern California coastal wetlands and watersheds have been dramatically altered by human activities over the past 150 years (Leet et al. 2001). The fragmentation and loss of habitat has resulted the threatened extinction of numerous wetland-dependent species (Dobson 1997). Development pressure on this area continues to be intense, with a doubling of the 1995 population expected by 2020 (SanDAG 2000).

The Southern California Wetland Recovery Project (WRP) was formed in 1997 in response to a need for increased regional coordination of wetland preservation, restoration, and management. The WRP is now a partnership among 17 state and federal agencies working in concert with local government, environmental organizations, and scientists to develop and implement a comprehensive plan for preserving and restoring the region's wetlands. The Science Advisory Panel (SAP) was established by the WRP Governing Board to ensure that the best available science is incorporated into the decision-making processes of the Wetlands Recovery Project and to advise the Board on regional goals, objectives, project criteria, and priorities. As of October 2000, the WRP Governing Board strengthened the role of the SAP in the WRP, providing funding to support a SAP staff member to facilitate SAP communication with Managers Group and County Task Forces.

Public interest in and funding of conservation and restoration activities remains high. Even in times of slow economic growth or recession, recent California voter approval of Proposition 40 providing funds for state lands acquisitions and clean water initiatives demonstrates this commitment (Stanley 2002). The WRP 2001-2002 work plan called for $50 million dollars in funding for acquisition and restoration projects, with an additional $100 million dollars to be matched by federal, state, local and private sources (WRP 2001). Given this significant taxpayer investment, the WRP must work to assure the most appropriate and efficient use of public funds. In doing so, the long-term effectiveness of wetland preservation and restoration efforts in southern California is one question that the WRP must ultimately address.

B. SAP Recommended Initiatives for Improving Bioregional Planning

Optimally, wetland preservation and restoration should be guided by a regional plan that includes a mix of habitat types, appropriately located within the landscape, to recover regional species diversity. However, the reality is that many projects are approved independently, driven by the needs of the wetland restoration proponent or of the wetland mitigator, or designed to benefit a targeted species without adequate regard for overall habitat requirements. Instead, the restoration efforts of the WRP and its partners should be driven by the regional priority to reestablish habitat types that historically have seen the greatest loss (Zedler 1996).

The WRP recently published its Regional Strategy, articulating the long-term programmatic goals and specific implementation strategies to guide the efforts of the WRP and its partners. The purpose of this paper is to build on this Regional Strategy by setting forth recommendations for improving the regional planning of wetland ecosystem preservation and restoration in southern California. It is our hope that this paper will be used to initiate a dialogue among WRP partners, and build support and momentum for the implementation of three initiatives designed to support better regional planning.

The WRP Science Advisory Panel (SAP) recommends the implementation of three major initiatives. These are the:

1. Establishment of quantifiable recovery objectives for wetland ecosystems;
2. Development of decision support tools to aid the WRP in prioritizing preservation and restoration activities; and
3. Development and implementation of a regional monitoring program to measure the progress towards these objectives.

This paper describes each of these initiatives in detail, as well the perceived need and expected benefits of implementing them. Chapter II includes the background explaining the connection between the WRP Regional Strategy and quantifiable recovery objectives, the philosophy with which the recovery objectives were developed, and a detailed explanation of each of the quantifiable recovery objectives. Chapter III details the development and recommendations for two types of projects that the SAP is advocating that the WRP undertake to provide decision support for prioritizing preservation and restoration activities. Chapter IV describes the need for a regional monitoring program, the recommended approach, the link between recovery objectives and monitoring, and SAP recommendations for implementing this program.

C. Definitions

Terms such as "wetland ecosystems" and "riparian areas" are used throughout this document, and it is important that we define these terms. There is no single correct definition of "wetlands" or "riparian areas." These zones lie on a continuum between terrestrial and aquatic environments, and demarcation of the boundaries often is not clear-cut. For the purpose of this document, the SAP chooses to use the U.S. Fish and Wildlife Service definition of wetlands:

> *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year"(Cowardin et al. 1979).*

The wetland ecosystems of southern California include five types or systems: marine, estuarine, riverine, lacustrine and palustrine wetlands (Cowardin et al. 1979). The glossary at the end of this document gives definitions of each of these types.

The definitions of "riparian ecosystems, areas, zones or corridors" can be somewhat confusing, and an explanation is necessary. The US EPA defines a riparian ecosystem as:

> "*…a vegetated ecosystem along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not have in all cases the characteristics necessary for them to be also classified as wetlands" (EPA 2001).*

This definition encompasses the wetlands that are an integral part of this ecosystem. The terms "riparian areas or zones" are sometimes used to refer to the transitional areas upland of wetlands that either 1) support predominantly mesophytic vegetation (trees, scrub and herbaceous cover) or 2) have soil that is predominantly non-hydric. Riparian areas are not just unique to the upland transition zones of riverine wetlands (in linear corridors), but can also be found in adjacent to palustrine, lacustrine and estuarine wetlands.

For the purposes of this document, we have chosen to use the term "wetland ecosystem" to include the wetlands, adjacent transitional deepwater and upland habitats. These adjacent habitats, which sometimes may include riparian areas, serve a role critical to the ecological function of the wetland, and are an important and integral part of WRP preservation, restoration and enhancement activities.

CHAPTER II. QUANTIFIABLE RECOVERY OBJECTIVES

A. Background

The SAP recognized the need for establishing quantifiable recovery objectives in the course of discussion of the WRP Regional Strategy. This document states that the long-term vision of the WRP is to "reestablish a mosaic of fully-functioning wetland systems with a diversity of habitat types and connections to the upland environment that preserves and recovers self-sustaining populations of species" (WRP 2001). To accomplish this vision, the six programmatic goals establish the intent to:

1. Preserve and restore coastal wetlands;
2. Preserve and restore stream corridors and isolated wetlands in coastal watersheds;
3. Recover native habitat and species diversity;
4. Integrate wetlands recovery with other public objectives;
5. Promote education and compatible access related to coastal wetlands and watersheds; and
6. Advance the science of wetland restoration and management in southern California.

These programmatic goals define the primary actions (preservation and restoration) and targets of these actions (wetland ecosystems), define the geographic scope (southern California coastal watersheds), and emphasize habitat and species diversity. They also establish ancillary goals that provide additional benefits to the public including improved water quality, storm flow management, education and public access, and a better understanding of wetland restoration and management in southern California.

Although the vision statement and six goals establish clear guidelines for WRP programmatic activities, there is a need to better articulate the major elements of wetland ecosystem structure and function that must be recovered in order to ultimately achieve the Regional Strategy goals. Articulating these elements establishes a more direct connection between management actions and the effects of those actions on the wetland ecosystem, and facilitates a science-based evaluation of WRP recovery efforts.

The term "recovery" as used in this document reflects two major concepts. First, "recovery" refers to a response by the wetland ecosystem to WRP restoration and enhancement activities. The second element of "recovery" is defined by the resilience of a wetland ecosystem to the natural and anthropogenic forces that affect its ambient condition of the resource. Watershed anthropogenic stressors including non-point sources of contaminants, importation of freshwater, increase of impervious surface area in the watershed, introduction of non-indigenous species, and development of adjacent upland buffers can adversely impact the condition of the resource, despite WRP efforts. Disturbances due to climatic variability such as El Niño-related rain events or processes resulting from global change such as sea-level rise can result in decreased acreage of coastal wetlands or degradation in the condition of riparian zones. The ability of a wetland to recover from natural catastrophic events often depends upon the degree to which its structure and function have been impaired by anthropogenic stressors. Coastal wetlands have the ability to migrate landward over time, but only if adjacent upland buffers have not been converted to urban land uses. A riparian zone is more susceptible to extreme flooding events when a greater percentage of its watershed has been converted to impervious surface (Booth and Reinelt 1993). However, we must recognize the existence of other forces, natural and anthropogenic, which occur within a watershed and affect the condition of wetland resources. Recovery must be evaluated not only in terms of the impact on WRP activities, but also by assessing effect of watershed stressors on the resource condition.

B. Importance of Habitat Type in Setting Recovery Objectives

Habitat is a collective term for the resources required by a species for its survival and reproduction -- the place where a species can be found (Odum 1993). Habitat includes not only the biological components such as the vegetation and fauna that serve as food sources and cover, but also the geologic, hydrologic and geomorphic processes that serve as the foundation for the biotic interactions. Recovery of a particular habitat requires enhancement or restoration of the various natural processes, structure, and functions that led to the development of that habitat.

The concept of "habitat type" is borne of the idea that many species share a common set of physical and biological resource requirements. "Salt marsh" and "mudflat" are two commonly used terms used to imply wetland habitat types. Wetland classification systems such as that of Cowardin et al. (1979) or Ferren et al. (1996) are more formal means of defining habitat types, with varying levels of detail. Although this document does not define the habitat types of southern California wetland ecosystems, it is important to understand how this concept can be used to develop quantifiable recovery objectives for the region.

There are two possible paradigms that could be used in developing the framework for quantifiable recovery objectives: 1) a species approach, in which restoration goals are based on providing optimal habitat for particular species of interest (i.e. dominant, threatened or endangered species), or 2) a habitat type approach, in which the objective is to restore habitat diversity with the assumption that high species diversity would be an expected outcome of the appropriate mix of wetland habitats in southern California. Restoration plans that are driven by the objective of creating habitat for a particular species can result in wetlands with a habitat type that may not support other important functions or is inappropriate given the landscape setting and hydrogeomorphic features of the site. For this reason, we strongly advocate the habitat type approach, with the underlying philosophy that the ecosystem as a whole is best recovered by approximating as close as possible the historical distribution of habitat types restored in their appropriate geographic or landscape setting. Emphasis should be placed on preserving and restoring habitat types that have experienced the greatest loss, while still retaining special consideration for threatened and endangered species. The SAP advocates this philosophy with the realistic understanding that, given the constraints imposed by an urbanized landscape, it may be difficult to completely replicate the condition and relative distribution of historic habitats.

The habitat type approach was used to develop a general set of quantifiable recovery objectives detailed below. The intent is that these objectives be applicable to all classes of southern California wetland (Cowardin et al. 1979; Ferren et al. 1996) and their adjacent and transitional habitats (e.g. riparian) habitats, that they have a direct link to management or restoration actions, and that they can be translated to indicators or measures to evaluate the success of those actions.

C. Linking Recovery Objectives to Management Actions

There are five major quantifiable recovery objectives:

1. Maintain existing and increase wetland ecosystem acreage
2. Recover habitat diversity to reflect historic distribution
3. Restore physical processes Recover biological structure and function
5. Recover landscape elements of ecosystem structure

These objectives describe the major elements of wetland structure and function that are critical to achieving the recovery of a mosaic of fully-functioning wetland ecosystems. They are also directly linked to the management, restoration, or enhancement activities undertaken to achieve these objectives (Table 1). These linkages are illustrated in Fig. 2a. It is important to recognize that these objectives operate within a hierarchy of spatial scales that range from the individual site to the drainage basin, watershed, and region (Fig. 2a-b). The effectiveness of these management actions and the progress of wetland ecosystem recovery can therefore be evaluated at several scales, depending on the management question. Separate indicators or different scaling of indicators may be necessary at these different spatial scales. Some objectives, such as the increase of wetland acreage restored or under protection, can be evaluated both for a particular site as well as for the watershed or region as a whole. Other elements, such as connectivity or habitat support for migratory birds, can only be assessed at the landscape scale.

Fig. 2a. Schematic of linkage between WRP vision statement, quantifiable recovery objectives, management or restoration actions, and feedback with monitoring.

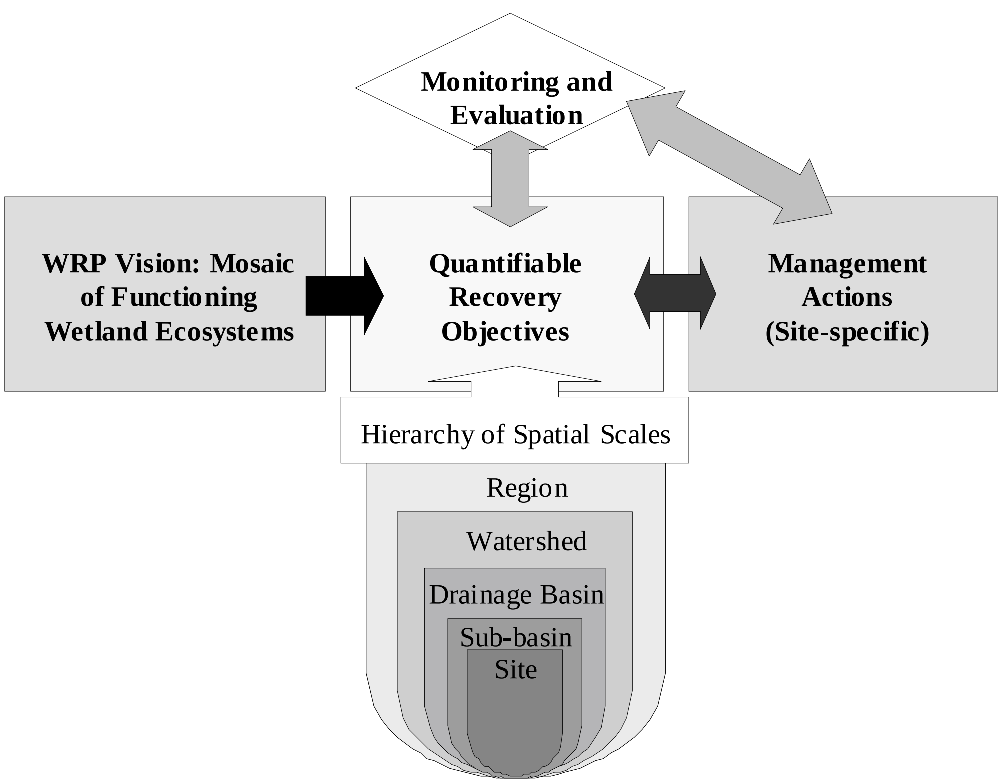
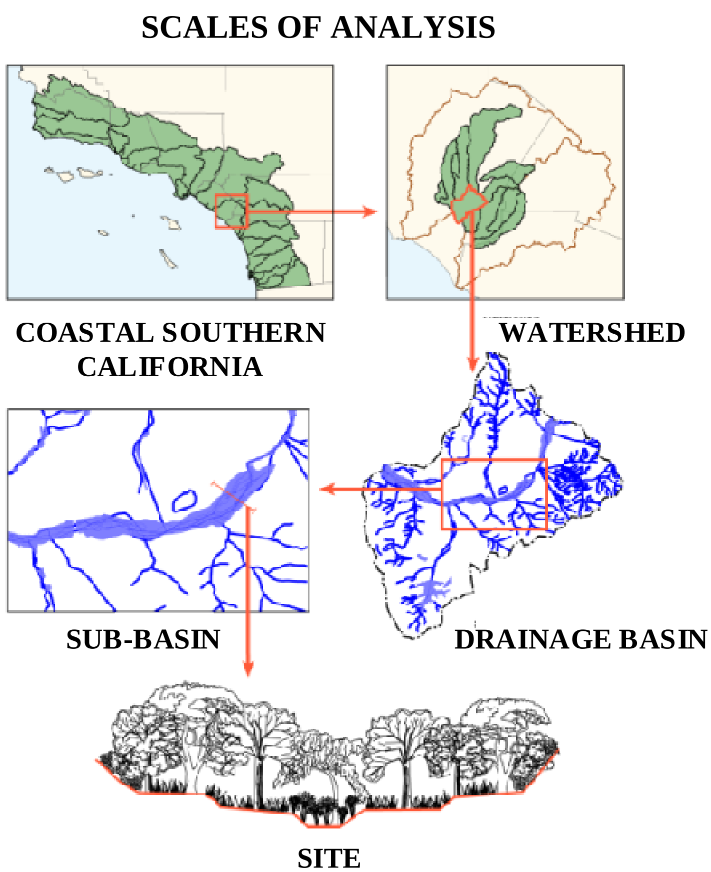


Table 1. General categories and specific examples of management activities

General Management Activity	Specific Examples
Acquire land	Acquire conservation easements
	Acquire fee title to property
Manage hydrology	Reconnect stream channel with floodplain
	Increase tidal prism
Manage physical structure of the site	Increase density of tidal channels
	Remove or set back levees
Manage biota	Remove exotic species
	Replant native vegetation
Control contaminant sources	Treat or divert wet- and dry-weather urban runoff
	Remove contaminated wetland sediments

Fig. 2b. Diagram depicting the hierarchy of spatial scales in which management actions and recovery progress must be evaluated.



D. Explanation of Quantifiable Recovery Objectives

1. Maintain Existing and Increase Wetland Ecosystem Acreage

State-wide, California has lost approximately 91% of its wetlands, reducing the total surface area occupied by wetlands from 5% of the land to less than one-half of one percent (Dahl 1990). 75% of the approximately 53,000 acres of southern California wetlands have been destroyed (CDPR1988), especially coastal salt marshes (CCC 1989; CDFG 1983; Zedler et al. 1992), riparian corridors (Faber et al. 1989), and vernal pools (Zedler 1987). A report of the California Coastal Zone Conservation Commission in 1975 estimated that 62% of the remaining wetland acreage has been "severely damaged;" given the population explosion in southern California in the past 25 years, this percentage is now likely to be much higher.

The loss of wetlands in southern California, along with degradation of those remaining, has greatly reduced the natural functions for which wetlands are so highly valued. These functions include 1) habitat to support native species biodiversity, 2) food chain support, 3) hydrological processes, including storm flow management and surface water storage and groundwater recharge, 4) sediment yield, transport and storage processes, and 5) biogeochemical functions important for water quality, including the cycling of organic matter and nutrients, and the trapping and transformation of pollutants (Mitsch and Gosselink 1986). In addition to loss of regional biodiversity, the alteration of hydrology and deterioration of water quality severely impacts the quality of one of southern California's most valuable resources: its coastal waters. The loss of wetlands in coastal watersheds has contributed to deteriorating water quality in beaches, coastal lagoons, bays, and the marine environment.

The restoration of these natural functions can be accomplished on a meaningful scale only if existing wetland ecosystem acreage in southern California is maintained and new acreage is created. There are two major types of actions that the WRP and its partners fund to maintain existing acreage and increase acreage: restoration and preservation. *Restoration*, in particular the re-creation of wetland habitat from other land uses, is the major means of increasing acreage. Excavation of fill dirt in what is now currently upland habitat in both Tijuana Estuary and San Dieguito Lagoon in San Diego County, and reclamation of riparian habitat converted to agricultural land along the Ventura River in Ventura County are among the several projects planned to increase wetland acreage.

Preservation includes the acquisition of fee title or conservation easements in wetlands, riparian areas, and associated upland habitats that are presently in private ownership and therefore not subject to conservation guarantees. Some of these parcels may be in pristine condition, while others may be degraded and require further enhancement to lift their functional capacity. The preservation of parcels such as the Huntington Beach wetlands in Orange County, Otay Mesa vernal pools complex in San Diego, or the Cold Creek riparian corridor and adjacent uplands reduces the risk of future loss and threat of degradation to wetland resources. The recent Supreme Court decision on the case of *Solid Waste Agencies of Northern Cook County v. U.S. Army Corps of Engineers* (known as the SWANCC decision) determined that regulation of wetlands beyond navigable waterways is the province of the state and local governments, thereby reducing the protection of Section 404 of the Clean Water Act for important isolated wetlands such as vernal pools and ponds, and intermittent and interrupted streams (Ruffolo 2002). The SAP highly recommends that the WRP continue to place a strong emphasis on non-regulatory means of preserving these under-protected wetlands and their transitional and upland habitats such as acquisition of fee titles and conservation easements. In addition the State of California should strongly consider the development of a statewide wetlands regulatory program that establishes clear protections for all wetlands and their transitional (riparian) and adjacent upland habitats.

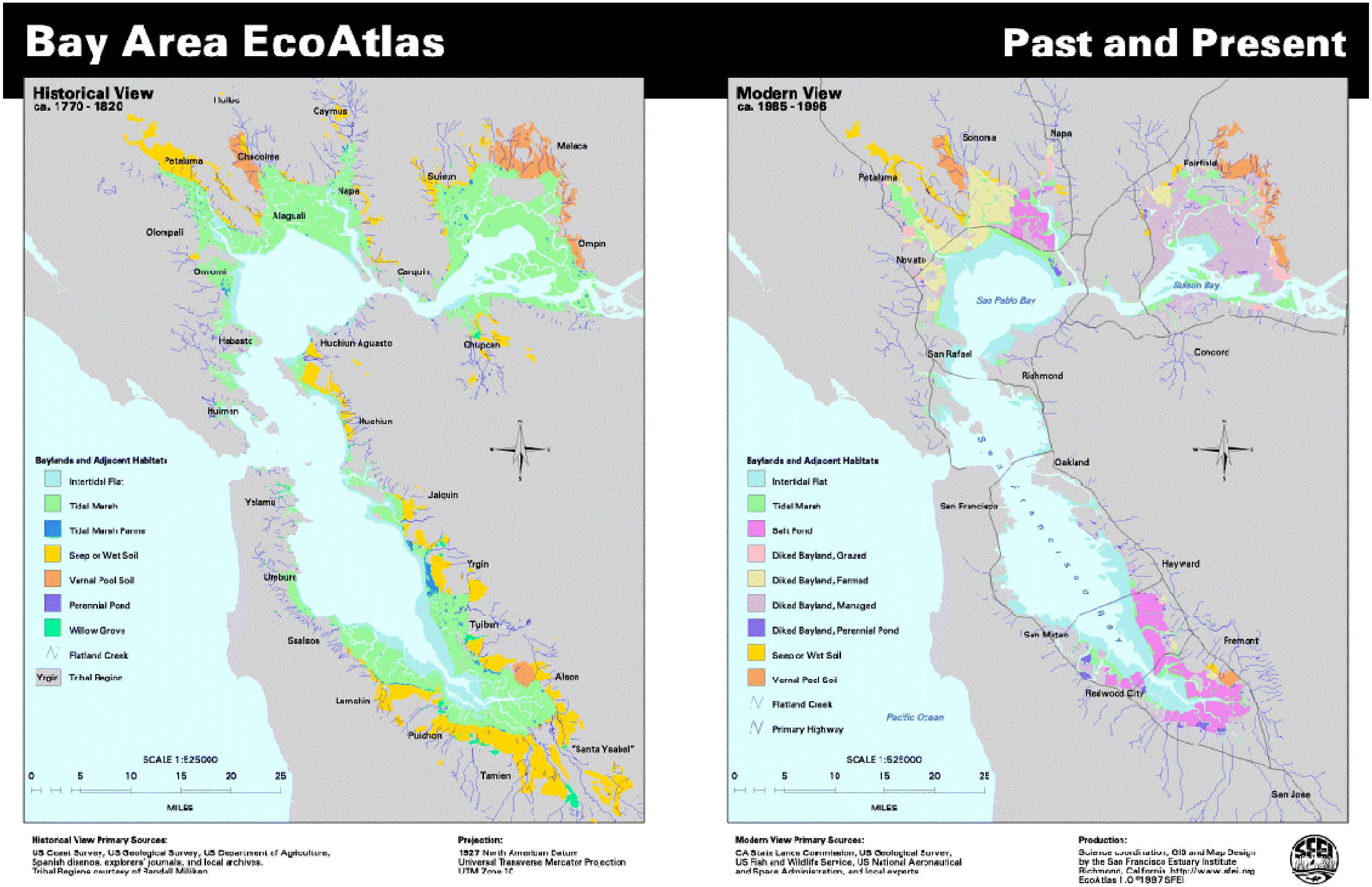
2. Recover Diversity of Habitat Types to Reflect Historical Distribution

The southern California coastal region is characterized by a great diversity in climate, topography, geology, and hydrology. The variability of these basic hydrogeomorphic elements, and the processes that are active within them, are responsible for the richness of wetland ecosystem types and the habitats found within them (Ferren et al. 1996). Southern California wetland ecosystems occur in a multitude of geomorphic settings, including floodplains, estuarine and lacustrine fringes, topographic depressions, slopes, and mineral or organic soil flats. The wetland's position in the landscape influences the physical processes that drive the hydrology, geomorphology, and chemical properties, and control the structure and function of the biotic community found there. Wetland habitat types cannot be restored if the underlying physical processes that originally resulted in development of that particular habitat are not reestablished. In order for restored or created wetland habitat types to be self-sustaining, they must be appropriately sited in the watershed.

The flora and fauna endemic to these wetlands have evolved life cycles that are dependent on the spatial structure, interspersion and connectivity of wetland and upland habitat types in the landscape. Thus, the recovery of high regional biodiversity of wetland-dependent species in southern California demands the restoration of the historical distribution of wetland habitat types and the physical processes that underlie them. Attention must also be paid to the spatial organization and distribution of these habitat types on scales from within the individual site to drainage basin, watershed, and sub-region.

European influence and modern development have considerably changed the southern Californian landscape and dramatically changed the spatial distribution as well as the profile of wetland habitat types (Ferren 1985; Macdonald et al. 1990). The extensive expansion of agriculture, urbanization and exploitation of natural resources have resulted in the filling, diking and fragmenting of wetlands, alteration of natural hydrology, diversion and pollution of water sources, and the extraction or harvesting of physical and biological resources. While some regional documentation of coastal resources is available from the late 19th and early 20th centuries, the detail in these information sources is limited. Despite this limitation, it is possible, using a combination of historical and present-day data and best scientific judgment, to formulate the historical profile of wetland habitat types and their spatial distribution. This historical picture can help to create a common vision for ecosystem restoration, and help to inform the process of setting regional habitat acreage targets (Gwin et al. 1999). Historical data assembled in the San Francisco Bay EcoAltas and used in the formulation of habitat goals are an excellent example of this concept (Goals Project 1999). Fig. 3 illustrates the comparison of historical versus

Figure 3. Comparison of historical (1770-1820) versus present-day (1965-1995) wetland acreage by habitat type in San Francisco Bay (diagram courtesy of San Francisco Estuary Institute, 2002)



present-day wetland acreage by habitat type in San Francisco Bay. Many of the historical sources used in the San Francisco Bay EcoAltas are also available for southern California. While some of this information has been drawn upon to characterize historic condition and habitat type distribution of particular wetland systems such as the Los Angeles River basin (Fig. 4; Rairdan 1998) or the Greater San Diego Bay Complex (Table 2; Macdonald et al. 1990), a complete regional picture of historical wetland distribution has not yet been assembled.

Table 2. Approximate Habitat Changes in the Greater San Diego Bay Complex[a]: 1856 – 1980s

Habitat	1856[b]	1902[c]	1984-87[d]	% Difference[e]
Salt ponds (diked)	0	24	1,252	----
Intertidal salt marsh	4,760	4,698	630	- 87 %
Intertidal sand/mudflats	6,186	5,641	1,005	- 84 %
Shallow subtidal:				
0 – 6 ft below MLLW	7,672	8,455	2,404	-69%
6 – 18 ft below MLLW	2,341	2,148	5,727	+ 136 %
Deeper subtidal:				
> 18 ft below MLLW	2,286	2,536	4,268	+ 87 %
Total Acreage	23,335	23,502	15,286	- 35 %

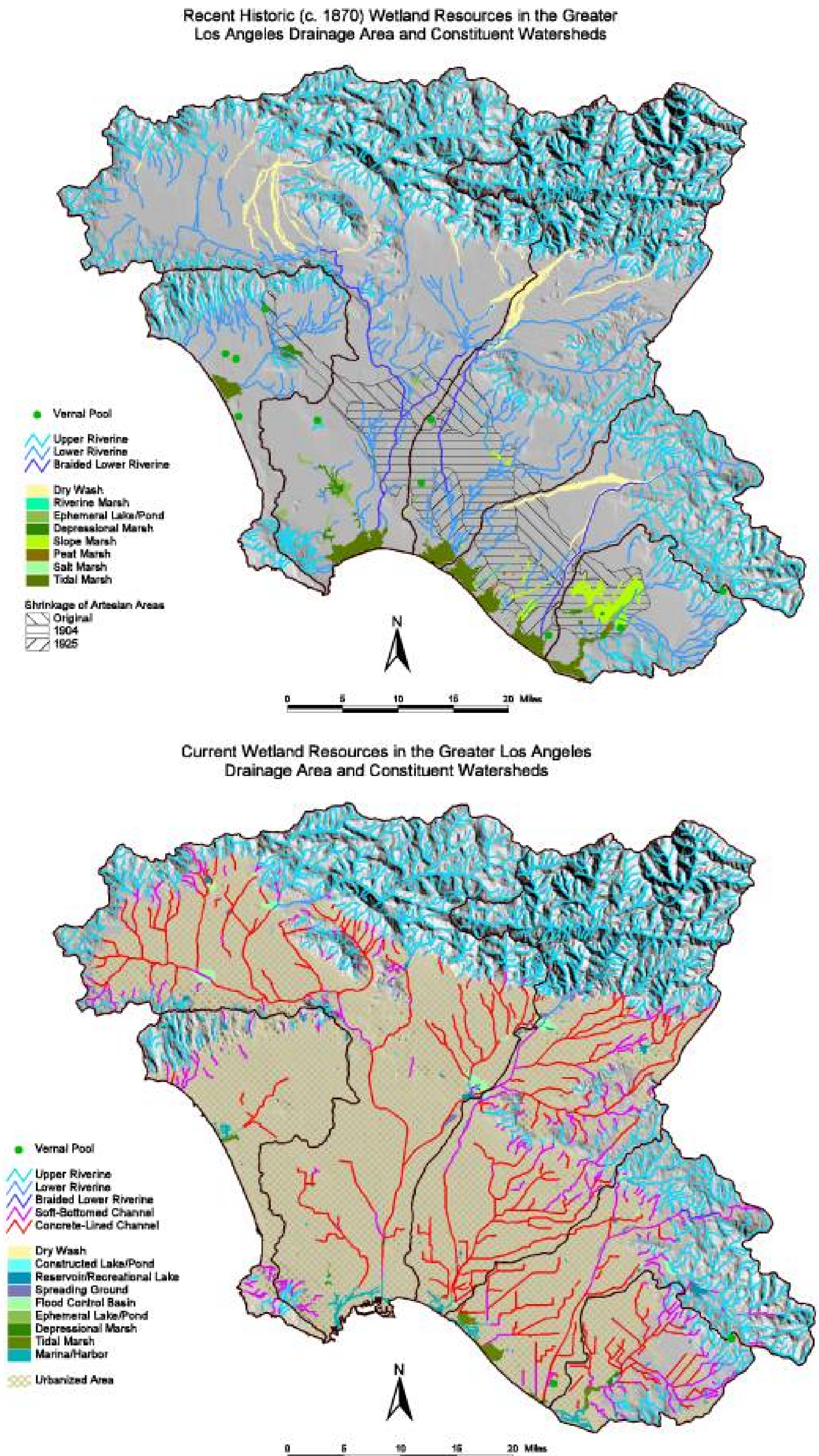
Notes: a. Includes Mission Bay, San Diego Bay, and Tijuana River Estuary
b. Uses 1856 Mission Bay data, except for intertidal salt marsh
c. Uses 1902 Tijuana River Estuary Data
d. Uses 1984 San Diego Bay, 1985 Tijuana River Estuary, and 1987 Mission Bay data (includes San Diego River Flood Control Channel).
e. Percentage loss or gain, 1856 through 1984-1987

Thus, the intent to "recover habitat diversity to reflect historical distribution," stated as a recovery objective, represents the philosophy to use historical data to the extent practicable to prioritize restoration of habitat types that have experienced the greatest loss. The SAP advocates the initiation of a project to document the historical acreage and distribution of southern California wetland habitat types. These data should be used to inform decisions on selecting priority habitat types for restoration, as well as to establish one benchmark to evaluate the long-term progress of the WRP regional wetland recovery efforts. As stated earlier, evaluation of this objective would take into account the constraints that result from undertaking restoration in a highly urbanized landscape. In many cases, several of the physical processes that are key to restoring a particular habitat type have been greatly modified. Examples include the perennial flow of imported freshwater (i.e. urban runoff) into salt marsh systems such as in the Ballona wetlands, or the hardscaping of stream bottoms, banks and adjacent land in the Los Angeles River. True restoration of the physical processes in these systems can only occur at considerable expense. WRP regional habitat acreage goals must realistically take these constraints into account (see Section III.A)

3. Recover Physical Processes

There are three major physical functions that control the physical processes that occur in wetlands. These are hydrology, sediment transport, and biogeochemistry. Each of these functions, and their principle attributes will be discussed in turn.

Figure 4. Map of historical (c. 1870) and present-day (1998) wetland resources in the Greater Los Angeles drainage area (courtesy of Rairdan 1998)



a. Hydrologic Functions

Hydrology is the primary driving force controlling wetland structure and function. For this reason, wetlands or riparian areas that have been hydrologically modified often have immediate visible impacts on their geomorphology (e.g. channel dimensions) and biological function (e.g. species composition, vertical structure, non-indigenous species invasions). Hydrological processes also affect the residence time of contaminants as they are transported through the system. Hydraulic residence time has a major impact on the biogeochemical rates of uptake and transformation in the wetland, processes that are very important in improving water quality.

There are generally two functions of hydrology in wetland ecosystems: energy dissipation and surface and sub-surface water storage and exchange (Brinson et al. 1995). In coastal southern California these processes operate on multiple spatial scales ranging from within a particular site or stream reach, to sub-basins and the entire watershed (Fig. 2a). An evaluation of recovery must address the processes operating at all of these scales. Elements of these processes are summarized below.

i. Energy dissipation

Energy dissipation is the reduction of the kinetic energy of water. Wetland ecosystems dissipate energy through rugged surface topography, channel form and roughness, sediment texture, and vegetation (Mitsch and Gosselink 1986). Steep headwater mountain streams dissipate energy with greater roughness due to irregular channel morphology, coarse bed materials including large boulders and woody debris. Towards the coastal zone (where generally channel slopes are less steep), floodplains, terraces, and other off-channel locations also provide additional area over which rapidly flowing water can spread. This attribute is particularly important in dissipating the energy from storm flows in riverine wetlands and adjacent riparian areas and in providing a protective buffer for shoreline development from storm or tidal surges. Hydrological modifications such as hardscaping stream channel bottoms or isolating river channels from their floodplains or downstream estuarine wetlands greatly reduces the capacity for energy dissipation during storms.

ii. Surface and sub-surface water storage and exchange

Many wetland ecosystems provide flow exchange and storage between surface and groundwater sources, a process that can occur locally between the water body and a shallow aquifer, or as an exchange with a deeper aquifer that crosses watershed boundaries (Tobias et al. 2001). In semi-arid environments like southern California, this is a particularly important function. Water may be stored above the surface, as shallow subsurface water in sediment porewaters or soil moisture in the saturated zone, or as recharge to groundwater. The capacity of a wetland and adjacent riparian area to perform this function depends on the surface sediment as well as the underlying geologic material. Hydrological modifications such as freshwater diversions, hardscaping stream channel bottoms or isolating river channels from their floodplains or downstream estuarine wetlands greatly reduces the capacity for surface and sub-surface water storage and exchange.

b. Sediment Yield, Transport, and Storage Processes

Wetland ecosystems can variably deposit, store, remobilize and transport sediment via surface waters. The characteristics of sediment deposition, storage, remobilization and transport are determined by the timing, quantity and duration of hydrogeomorphic processes acting on the drainage basin. The relative importance of these factors and their effects on channel morphology and biotic community varies depending on landscape position (and therefore wetland class). Therefore, riverine wetlands have very different sedimentary processes than do estuarine or lacustrine wetlands. Modifications in hydrology (i.e. timing, magnitude, or duration of flow) or changes in sediment yield in the watershed can greatly impact wetlands, causing shifts in habitat types either by infilling from accelerated sediment delivery or wetland loss from sediment deprivation. There are several aspects of sediment yield, transport, and storage processes that should be considered the recovery of physical processes. These are discussed below:

i. Sediment Yield

Sediment yield to wetlands and adjacent riparian areas is a function of sediment sources, watershed position, hydrologic conditions, and the type of sediment being transported. Sediment from source areas is transported down watershed through a number of processes including: mass movement (the gravity-controlled movement of soil and rock downslope); hillslope processes (including sheetwash erosion, rilling, and dry ravel), and fluvial processes occurring in stream channels (Collins and Dunne 1990). Dominant sediment source areas and transport processes often have recognizable characteristics within a watershed. For example, landslides, may yield sediments with a grain size distribution similar to hillslope materials while storm-generated runoff may typically result in clay, silt, and sand sized sediment transport and delivery. The post-fire erosion environment is particularly important in southern California, whereby erosion rates may increase tremendously during the 3-5 years following a fire depending upon rainfall conditions. Many of the alluvial valleys of coastal southern California have overbank deposits, or older Pleistocene-formed stream terraces, which can either store upstream materials or contribute sediments towards downstream yields when a channel system is undergoing systematic adjustment. Actively incising streams, either caused by natural geologic processes towards equilibrium or due to anthropogenic forces in the watershed will also shed increased levels of sediment downstream (Madej 1982).

In all cases, the quality of the sediment supplied (grain size, texture, and chemical properties) is a function of the geology of the source material, the type of process, and landscape position. Anthropogenic activities can affect the rate at which these processes yield sediments to the drainage network. Urbanization increases the impervious area in a watershed, resulting in reduced infiltration and increased runoff response to rainfall. Urbanization thus often results in greater runoff volumes, and higher peak flow rates.

Depending upon sediment supply conditions, increased runoff and streamflow energy due to urbanization often leads to increased sediment yields, particularly during the construction build-out phase within a watershed. Agriculture and development of roads are also increase sediment yield (Reid and Dunne 1984). In the post development scenario, watershed sediment sources are often reduced or structurally disconnected from passing materials downstream coastward.

Storage of sediment behind dams along many of the coastal drainages of southern California has prevented beach renourishment downstream.

As a result of increased development and disturbance in the watershed, sedimentation rates in coastal wetlands have substantially increased. Onuf (1987) showed a 40% decrease in the volume of Mugu Lagoon due to anthropogenic increases in sediment input. Calhoon et al. (1996) measured extremely high rates of sediment accretion (up to 8 cm yr-1) from storms in the early 1990s. These rates are much greater than long-term rates and likely contribute to habitat conversion with the estuary (Mudie and Byrne 1980; Weis et al. 2001).

ii. Transport, Deposition and Storage of Sediments

The transport, deposition and storage of sediments in stream, rivers and estuaries is highly variable, both spatially and temporally. It is the interaction of hydrologic processes, landscape position, and sediment yield to the system that control the transport, deposition, and storage of sediments. This in turn controls the physical structure of the channel, banks, and floodplain, and elevation of wetland sediments – a critical aspect of habitat.

As rivers undergo a downstream reduction in gradient, the energy to transport sediments decrease, and the coarsest portion of the bedload and suspended load are deposited (Collins and Dunne 1990). This downstream reduction in channel gradient is associated with downstream reduction in grain size for deposited materials. Sediment deposits (stored within an integrated channel, floodplain, and terrace system) may rest in place for periods ranging from a year, to decades, to even centuries, depending upon the frequency and magnitude of storm events required to initiate transport.

Anthropogenic activities in watersheds, and modifications to rivers, lagoons, and estuaries can cause a major change in the transport, deposition and storage of sediments throughout the drainage network (Reid and Dunne 1984). Structures such as Arizona crossings, tide gates, drop structures, dams, and other types of impoundments change channel gradients and cause changes in the sediment transport regime. The drainage network downstream of an impoundment is often starved for sediments, a major problem in maintaining a steady supply of sand to beaches. In estuaries such as the Buena Vista Lagoon in San Diego County or Mugu Lagoon in Ventura County, the presence of berms, tide gates and culverts dampens tidal flow exchange and limits the seaward transport of sediments (Onuf 1987). This causes the system to aggrade, becoming progressively shallower. As in Tijuana Estuary, coastal wetlands aggrade when watershed anthropogenic activities cause major changes in sediment yield, resulting in increased erosion, net deposition downstream, and major loss of habitat (Calhoon et al. 1996).

c. Biogeochemical Functions

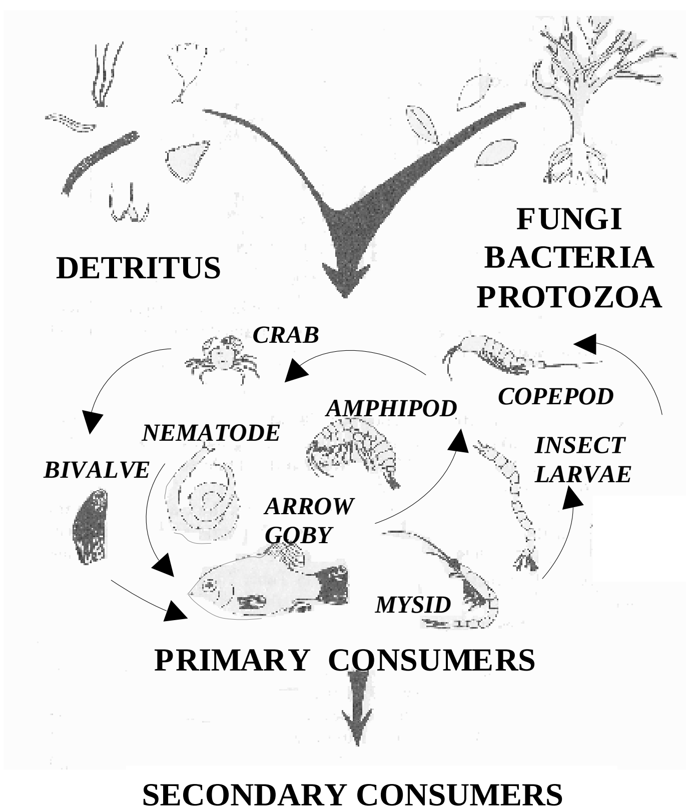
The biogeochemical functions of wetlands are an interdependent array of mechanisms that control biological productivity and the quality of habitat provided by a wetland, as well as water quality benefits it provides. The processes of chemical transformations, adsorption and desorption, flocculation, precipitation, as well as the biological uptake, transformation, and release of elements and compounds make up just some of the biogeochemical functions exhibited by wetlands (Mitsch and Gosselink 1986). Together, these biogeochemical functions control:

i. Cycling and export of detrital organic matter

The cycling and export of organic matter in the form of detritus is an important factor in maintaining high biological productivity and food chain support within a wetland and adjacent habitats (Day 1989). Leaf and tree litter, decaying algae, dead animal tissue and feces provide fuel for growth of fungi, bacteria and protozoa and are consumed directly by some invertebrates and fishes. As organic matter decomposes, nutrients are released, providing the building blocks for the growth of plants and algae. Consumption of microorganisms, plants and algae by primary and secondary consumers organisms transfers the organic matter up the food chain (Fig. 5). Wetlands sediments are a good example of the importance of detritus in supporting biological productivity. The incorporation of detritus into the wetland sediment provides organic carbon, nutrients and texture critical for the establishment of healthy plant communities. Wetland sediments with low organic carbon or nitrogen content retard development of plants with appropriate biomass, density, and vertical structure, and have been sited as reasons for which projects haven failed to meet habitat restoration objectives (Zedler 1996b).

Figure 5. Schematic of a wetland detrital food chain showing transfer of organic matter and energy through primary and secondary consumers (Day 1989)

WETLAND DETRITAL FOOD CHAIN



ii. Cycling of macro and micro-nutrients

Nutrients are the building blocks for the growth of plants and algae in wetlands. The quantities available and how they cycle restricts to a great degree the kind of biotic communities found there. Plant macronutrients including nitrogen, phosphorus, and potassium are required in major quantities for growth. Micronutrients such as including iron, manganese, molybdenum, cobalt, and copper are needed in very small quantities and can be toxic in larger doses. Many vitamins and most minerals are also critical micronutrients for wetland fauna, and needed in small quantities to maintain function because the animal itself cannot synthesize them. The cycling of these macro- and micronutrients in wetland ecosystems represents an important set of biogeochemical processes critical to the maintenance of biological function. Many aquatic biota in west coast streams and estuaries have evolved to thrive in conditions produced by low macronutrient concentrations (Kamer et al. 2001). An increase in the quantity of nutrients available often causes increases in algal biomass and large fluctuations in dissolved oxygen in surface waters and sediments. These changes over time can cause a shift in community composition, particularly in invertebrates and periphyton, and an overall reduction in biodiversity (Childers et al. 2001).

iii. Uptake, sequestration, and transformation and release of contaminants

Wetland ecosystems are highly valued for their ability to take up, sequester and transform anthropogenic sources of contaminants. These complex interactions are responsible for the water quality cleansing functions of wetlands. Bacteria mediate a whole host of reactions, including the removal excess inorganic nutrients or converting them to a less biologically reactive form and the sequestration or transformation of heavy and trace metals so that they are effectively removed from the surface waters (Gambrell 1994). The degree to which these functions enhance water quality is dependent on the wetland’s position in the landscape, the geology of the region, hydrologic regime, the chemistry of the water and soils, and the flora and fauna that inhabit the wetlands. The benefits provided by a wetland to a watershed often begin to deteriorate when the level of anthropogenic disturbance (i.e. level of contamination, changes in hydrology) exceeds the system’s capacity for resilience. After this point, biogeochemical functions decline as the disturbance affects permanent changes in biotic community composition and the biological functions so critical in controlling the biogeochemistry (Childers et al. 2001). Thus large-scale changes in watershed hydrology, land use, and dominant biotic communities are often visible in the alteration of biogeochemical functions at a particular site.

4. Recover Biological Structure and Function

The biological structure and functions found in wetland ecosystem are the result of a complex set of interactions between the physical processes that provide the foundation for habitat and the community of biota that utilize and modify the habitat. The opportunity to see this mosaic of flora and fauna in their natural state is one of the values that humans prize in wetlands. Also greatly valued, these organisms are responsible for the important biogeochemical cycles that result in improvements to water quality.

Anthropogenic stressors can alter the biological structure and function in wetland ecosystems. An important part of evaluating restoration or recovery of a system is to evaluate the structural and functional integrity of its biological community. As with the physical processes, evaluation of this objective must take in account the variety of spatial scales, site-specific to drainage basin, watershed and region, that play a role in how the biota interact and function. These spatial scales are inherent in the important elements of biological structure and function, outlined below:

a. Native Species Biodiversity

The number of species, often referred to as species richness, is the oldest concept of biological diversity (Krebs 1999). While diversity is also discussed at the level of genetics, habitats (see Objective 2 in Section II.D.2), and ecosystems, this element of biological structure and function is centered on the diversity of species – within a site, between sites of similar habitat types, and for the region as a whole. In addition to species richness, another important element of biodiversity is that of heterogeneity, or the relative abundance of species. Communities are considered to be more diverse when there are more species and when the species approach equal abundance (Krebs 1999).

The ability to support characteristic native plant, invertebrate, and vertebrate biodiversity is one of the most basic attributes used to assess the level of biological functioning (Zedler 1996b). Higher native plant diversity improved the development of function in restored salt marsh including a more complex canopy (Keer and Zedler 2002), great biomass accumulation, and nitrogen retention (Zedler et al. 2001). Failure to maintain biodiversity can occur when the wetland habitat is disturbed by any number of anthropogenic and natural stressors (i.e. contaminants, hydrological modifications, invasions by exotic species, catastrophic flooding, drought). Although populations of native species undergo natural fluctuations in abundance, long-term declines in native species biodiversity and changes in relative abundance are indicative of the loss of biological function. The objective of maintaining high biodiversity of native species should be assessed by long-term changes in the populations of not only of threatened and endangered species but also keystone or indicator species characteristic of wetland habitat types. These attributes are important to monitor within and among wetland ecosystem habitat types, as well as for the southern California region as a whole.

Invasion by exotic species is a serious threat to the maintenance of regional diversity of native species in southern California wetlands (Zedler 1996b). Exotic plant species can invade wetlands if the substrate is disturbed or if hydrological modifications cause a change in habitat type or soil salinity. Many mediterrean exotic plants thrive under low salinity conditions and do best in areas with excess urban runoff (Callaway and Zedler 1998; Kuhn and Zedler 1997). An alien plant species can be a particularly successful invader if it has high seed production, high germination rates, and the ability to spread vegetatively (Zedler 1996). Contaminated water sources such as urban runoff or ship ballast water are often excellent vectors for exotic species.

b. **Maintenance of Spatial Structure and Distribution of Plant Associations, Aquatic and Terrestrial Invertebrates and Vertebrates**

Biological communities have structure, not only in terms of species richness and abundance, but also the spatial and temporal patterns of floral and faunal distributions in the habitat. For plants, structure can imply the plant associations, growth form (such as plant or canopy height), and vertical stratification (as is found with trees, shrubs and herbaceous cover). Canopy architecture has been shown to be an important attribute of habitat for several bird species. The presence of tall cordgrass in the low salt marsh habitat has been shown to be important for nesting of the light-footed clapper rail (Zedler 1993). The height and cover of glasswort are important attributes of the clapper rails refuge during high tide (Zedler 1996b). Pickleweed branches of sufficient height and strength are important to the endangered Belding's Savannah sparrow because the birds perch on the highest plants available to defend their territory (Powell 1993). For herbivores and carnivores, the proximity, diversity, and abundance of food sources, and the proximity and nature of refuge are important aspects of the spatial structure of habitat (Power and Rainy 2000).

c. **Maintenance of Predicted Food Web Linkages and Trophic Levels**

The transfer of energy as food through the different trophic levels is referred to the as the food web (Krebs 1999). Each of the trophic levels -- producers (green plants), primary consumers (herbivores), secondary consumers (carnivores, parasitoidal insects), tertiary consumers (higher carnivores) – can be further classified into *guilds*, which are groups of species exploiting a common resource base in a similar fashion (Root 1967). Within each of these trophic levels, the guilds of species play basic functional roles in the wetland biological community.

Recognition and monitoring of the trophic levels and guilds is an important element to evaluate the level of biological function of wetland ecosystems. For example, Kwak and Zedler (1997) found that intertidal macroalgae, marsh microalgae and *Spartina foliosa* served as an important food base for salt marsh invertebrates, fish, and the light-footed clapper rail. The loss of species (either locally or regionally) or reduction in a guild of species through habitat loss can radically change the flow of energy and materials through the food web, and reduce abundance of consumers (Meffe and Carroll 1997). The addition of exotic species can also change food web structures by occupying important niches in habitat previously utilized by native species. Replacement of these native species eliminates them as a food source, thus changing the food web structure and energy flow.

Changes in the abundance or biomass of a particular trophic level guild are also a critical factor affecting food web linkages and overall ecosystem health. As the lowest level in the food web, the production of plant and algal biomass is an important attribute controlling the structure of the food web. The standing biomass and annual production of vascular marsh plants and riparian trees, shrubs, and herbaceous plants are often used as a indicator of ecosystem health. Aquatic plant and algal productivity is also extremely important; Covin et al (1988) found that macroalgal production in southern California wetland surface waters was equal to that of vascular plants. Many aquatic plants and algae such as seagrasses, macroalgae, periphytic algae, and phytoplankton, are extremely susceptible to increases in nutrient loading, particularly from anthropogenic sources (Fong et al. 2001; Kamer et al. 2001). Nutrient inputs result in increases in algal biomass, often resulting in low oxygen events and fish and invertebrate die-offs.

5. Recover Landscape Elements of Ecosystem Structure

In general, landscapes are highly organized, interacting mosaics of terrestrial and aquatic habitat types with structure inherent on many spatial scales (Fig. 6a-b). Geomorphic position and the sum of tectonic, geomorphic, hydrologic, and geochemical processes acting on the landscape determine the unique assemblage of wetland, riparian, and upland habitat types found there. As mentioned in the previous section, flora and fauna endemic to southern California wetlands have evolved life cycles that are dependent on the complex mosaic of wetland and upland habitat types in the landscape (Ferren et al. 1996). Anthropogenic activities can disrupt the structural integrity of landscapes and can radically alter the movement of material and organisms across the landscape (Garder et al. 1993). A regional plan for the recovery of southern California wetland ecosystem must restore the structural components and processes operating at various spatial scales.

Figure 6a. Mosaic of habitat types within a riparian corridor (adapted from USDA 1998)

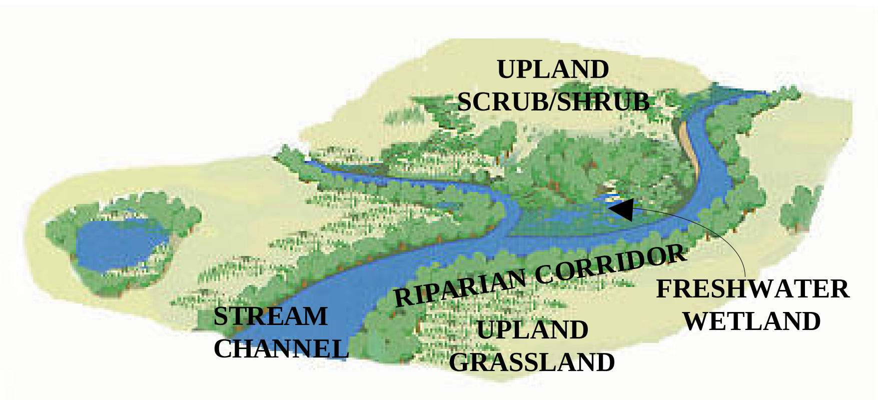
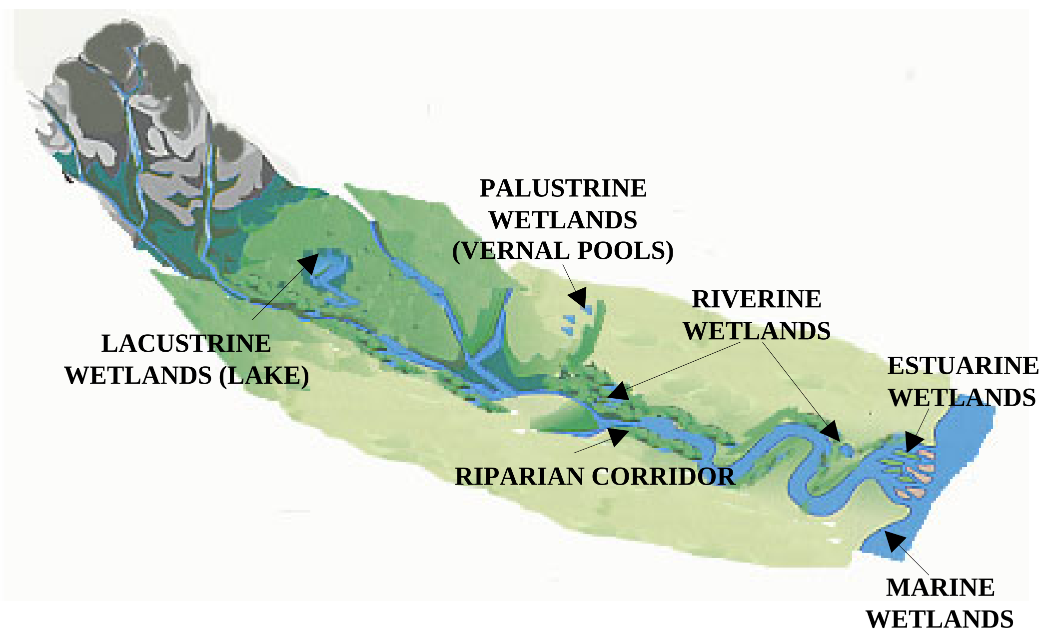


Figure 6b. Diagram showing landscape position of different wetland types (adapted from USDA 1998)



Important elements of ecosystem recovery that can be evaluated at the landscape scale include:

a. Habitat interspersion

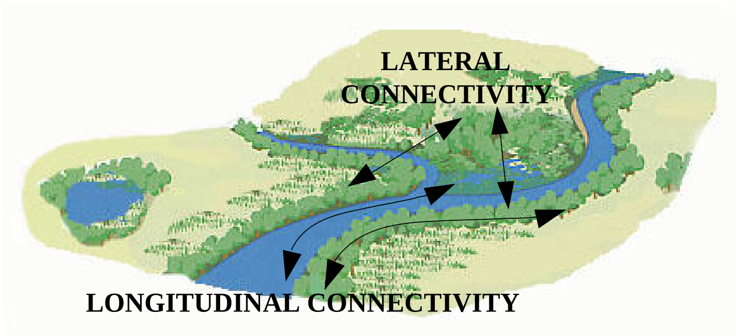
Aquatic, semi-aquatic, and terrestrial organisms utilize wetland ecosystem extensively to complete portions of their life cycles (i.e. reproduction, feeding, growth, refuge, etc.). The interspersion of habitats refers to the mixing of different habitat types in a patchwork pattern necessary for plants and animals to complete their life cycles (Fig. 6a-b). Monocultures typical in agriculture result in low or no habitat interspersion. Areas with high interspersion have habitat types with a high edge to area ratio, producing a multitude of ecotones that enhance biodiversity and biological function.

Adjacent uplands often include or once included grasslands, various types of coastal scrub (e.g., dune scrub, bluff scrub, delta scrub, coastal sage scrub, and chaparral) and oak woodland. Many plant and animal species depend on the continuity of the transition from wetland to upland to survive in an area. For example, edge-dependent species of southern California coastal wetlands include mammals (e.g., Salt Marsh Shrew, Southern California Salt Marsh Harvest Mouse), birds (e.g., the state-listed endangered Belding's Savannah Sparrow, which nests in salt marshes and also forages in adjacent uplands), plants (Salt Marsh Bird's Beak) and butterflies. An insect-pollinated annual, the Salt Marsh Bird's Beak relies primarily on bees for pollination. Development of adjacent upland areas may have greatly reduced foraging and nesting habitat for the pollinators, thus reducing the production of viable seeds in the bird's beak (Fink and Zedler 1991). The caterpillar of the Pygmy Blue Butterfly eat only marsh and edge species of plants belonging to the Spinach Family and the caterpillars of the Wandering Skipper eat only Saltgrass. Adults of both butterflies nectar mostly on summer and fall flowering plants belong to the Sunflower Family that occur in adjacent palustrine marshes (e.g., Western Goldenrod) and shrubs of coastal scrub, grassland, and dune habitats including Coast Golden Bush and Mock Heather. Because many native coastal butterflies are dependent on specific host plants, without an appropriate mix of native habitats that support native plant communities, these edge-dependent species are not likely to survive in wetland ecosystems.

b. Habitat connectivity

Connectivity refers to the connection between habitat types, allowing for flora and fauna to enter, utilize and leave the habitat via large, contiguous patches (Fig 7). These patches occur on a variety of spatial and temporal scales that vary as a function of each animal's perceptions (Wiens 1976; Wiens 1989). At high tide and during flood tides, estuarine birds such as the federally-listed, endangered Light-footed Clapper Rail move into uplands contiguous to salt marsh habitat and can hide from predators if sufficient and appropriate vegetation cover exits. Raptors such as the White-tailed Kite forage in upland grasslands, transitional wetlands, and high salt marsh habitats for small mammals such as the Southern California Salt Marsh Harvest Mouse that is confined to the edges of estuaries. Thus, connectivity from the perspective of salmonid fishes differs from that of large mammals, amphibians, or birds. Many wetland species such as fishes, reptiles and amphibians are not capable of migrating overland if the connectivity of the wetland habitat is obstructed. While many migratory or wetland-dependent birds have the capability of flying to other habitats, the regional patchwork and connectivity of wetlands become important for these species.

Figure 7. Diagram illustrating concept of lateral and longitudinal habitat connectivity (adapted from USDA 1998)



c. Regional water budget

Hydrology is one of the major controls on wetland ecosystem structure and function, and alteration of the region’s water budget is one of the major constraints on restoring biological and physical functions to historic levels. Given the relatively arid climate of southern California, historical agricultural development and subsequent urbanization have required aggressive development of local surface and groundwater resources, and ultimately importation of water from outside the region. Local water withdrawals often lower streamside water tables cutting support for riparian vegetation and reducing dry-weather stream flow. Conversely, increased runoff from agricultural irrigation and urban impervious surfaces increases the frequency and height of channel-altering storm flows and often increases dry-weather flows. Since the geomorphology of stream channels is directly related to their flow, these broad changes in the regional water budget cause changes in stream structure and function (including controls on erosion and sediment transport). Similarly, since the native riparian and stream biota have evolved in concert with pre-disturbance flow regimes, alteration of these regimes can stress native plants and animals, increasing their susceptibility to competition and invasion from non-natives. The SAP recommends that the WRP prioritize projects that give the greatest functional lift or recovery to landscape hydrologic processes. Projects such as removal of dams or reduction in the quantity of imported freshwater are most likely to move the regional water budget towards its historic condition, and are therefore likely to have a far-reaching impact on the recovery of individual sites throughout the watershed.

d. Landscape hydrologic connectivity

Landscape hydrologic connectivity refers to continuity of exchange in three dimensions: 1) vertical connectivity between surface and sub-surface flows 2) longitudinal connectivity between the coastal ocean, estuaries, rivers and their upstream tributaries, and 3) lateral connectivity between wetland and associated transitional (riparian) or upland habitats. Hydrological modifications resulting from isolating of river channel from their floodplains, or which result in channel incising or infilling can disrupt the hydrologic connectivity, and negatively impact water quality and biotic community of that system. Historical data generally show a pattern of narrowing stream corridors and simplification of habitat types along southern California streams over time. Side channels and backwaters have been cut off or lost, wetland and riparian zone vegetation have been reduced to narrow fringes along stream channels. Reversing these trends will likely require first understanding, and then reestablishing or enhancing, the landscape hydrologic connectivity in all three dimensions.

CHAPTER III. DECISION SUPPORT FOR PRIORITIZING PRESERVATION AND RESTORATION ACTIVITIES

In recommending the five quantifiable recovery objectives, the SAP has identified the numerous elements of wetland ecosystem structure and function important to recovery. Prioritization is the process by which these objectives are translated into decisions by identifying ecological criteria that are most likely to result in improvements to the resource. Establishing priorities will the aid the WRP in reaching its recovery objectives and the long-term vision by maximizing the ecological and socio-economic benefits and probability of success. While the socio-economic benefits and cost are clearly an important consideration in prioritizing projects, the SAP does not currently represent the expertise required to advise the WRP on these issues. Therefore the discussion of decision support is limited to consideration of the ecological aspects of prioritization. Within the realm of WRP activities, the SAP recommends that prioritization take place on two different levels:

1. Setting habitat acreage targets for wetlands areas, and
2. Determining priority areas for preservation and restoration of riparian corridors in coastal watersheds.

A description of each of prioritization on each of these levels is given below.

A. Habitat Acreage Targets for Wetlands

Prioritizing the wetland classes and habitat types which have experienced the greatest loss for preservation and restoration is the means by which the WRP can achieve the second recovery objective: recovering regional habitat diversity to reflect the historical distribution of these habitats in the southern California landscape. The SAP recommends that the WRP develop a shared vision of the changes needed to improve the ecological functions and regional biodiversity of our region's wetlands. These targets can be developed by either or a combination of two principal strategies:

1. Comparison of historical versus present day wetland acreage by habitat type;
2. Developing the habitat requirements of common as well as threatened and endangered species using monitoring data and best professional judgment

Prioritization of preservation and restoration should driven by the objective of maximizing regional habitat diversity by restoring wetland habitat types to a ratio that approximates what was once found on the landscape (see Section II.D.2). Given the lack of detailed historical information, this strategy may produce limited results. However, an effort should be made to recover and document from various regional and local data sources the historical inventory of wetlands (see Section IV.C). To the extent necessary, this effort should be supplemented by evaluation of the habitat acreage needs of species representative of habitat types, as well as acreage required to support self-sustaining populations of threatened and endangered species. A combination of both strategies was successfully utilized in the S.F. Bay area to derive habitat acreage goals for tidal wetland preservation and restoration (Goals Project 1999).

Development and, particularly, urbanization of southern California coastal watersheds has made it unlikely that we can completely restore the wetland ecosystems to previous historic habitat types, surface area and level of functioning. In many cases, the technical and economic constraints imposed by urbanized land uses and altered physical processes force the restoration of habitat types that are not historic but rather reasonable and feasible. The SAP does not envision the recommended habitat acreage goals to be a rigid template, but rather a guide to focus on restoration priorities for the region as a whole.

Using either or a combination of the two strategies to set habitat acreage goals, two issues should be clear. First, the use of historical inventory data as well as the habitat needs of wetland dependent species relies a great deal on best scientific judgment based often on limited data sources. Second, it will be impossible to maximize habitat for all species. In the process of setting habitat acreage targets, the WRP will to need make some difficult policy decisions. Thus, the scientific knowledge and data that support the habitat acreage targets reflect the current state of understanding as well as conservation and restoration policies; it is anticipated that the habitat acreage targets should be revisited periodically in the future to reflect improved understanding of historical conditions and habitat requirements as well as practical experience in restoration.

Implementation of a habitat goals project is contingent on development of data sources for such an assessment. There are two major data sources: 1) historical inventory of wetland resources by habitat type, and 2) monitoring data used to develop habitat requirements of common as well as threatened and endangered species. The SAP recommends that the WRP support the development of a historical inventory, and catalog the availability of monitoring data that could be used to support the development of habitat acreage goals. This effort can be carried out concurrently with other ongoing efforts to develop a regional monitoring program and other decision support tools (see Section III.B and Section IV), and as such will also be complementary to those efforts as well.

B. Determining priority areas for preservation and restoration of riparian areas in coastal watersheds

Unlike coastal (tidal) wetlands where opportunities for restoration are limited, the preservation and restoration of riparian areas in the approximately 10,000 sq. miles of southern California coastal watersheds presents a formidable challenge for the WRP. To come up with a coherent regional strategy for project funding, the WRP must determine which riparian areas most merit preservation and restoration from an ecological perspective. This determination must be based primarily on a comparison of the ecological attributes of the an area, both in terms of how the riparian area might potentially contribute to the functioning of the watershed, as well as how watershed processes may affect the site’s structure and function.

The SAP recommends that the WRP pursue the development of a decision support tool that will aid in identifying high priority riparian areas for preservation and restoration. It is our intent that the WRP Manager’s Group will utilize the results of such an assessment to identify regional priorities to guide annual project selection. This tool also can be used by WRP County Task Forces as a preliminary screening tool to develop priorities for preservation and restoration as a part of the watershed management planning process.

1. Decision support tool project description

The NOAA Coastal Services Center has agreed to provide the WRP with the technical expertise to adapt the Spatial Wetlands Assessment for Management and Planning Model (SWAMP) as a decision support tool. The SAP has already begun to work with the WRP Managers group and County Task Forces to develop this tool. SWAMP, a geographic information system (GIS) based model, would be used to examine the ecological significance of a wetland to its watershed, as determined by the measured contributions of that wetland within three primary categories: habitat, hydrology, and biogeochemistry (water quality). One attractive feature of the conceptual framework behind SWAMP is that it allows the decision maker the flexibility to establish the rules and relative weights that determine the overall rating assessed for a riparian area. In the process of establishing rules and relative priorities, the WRP partners will engage in a public discussion of the attributes of riparian areas that are important in determining preservation and restoration potential, and the relative importance of each.

As envisioned by the SAP, the development of the decision support tool would undertake two principal tasks:

- Conduct a regional scale assessment of riparian zones to identify those areas with high preservation and restoration potential. This assessment would be performed for the southern California coastal watersheds that are entirely or partially contained within the five southernmost coastal counties (Fig 1).
- Incorporate assessment indicators into a user-friendly, GIS-based decision support tool. Features of this tool will allow the user to customize analyses to better reflect the local conditions of the resource in a watershed or group of watersheds.

The application of the SWAMP approach to southern California will address both preservation and restoration of riparian areas. Preservation priorities will be determined by assessing the ecological integrity of the riparian area, and examining the degree to which, by preserving the site, there is a decreased risk that the watershed and/or sub-region will experience a decline in the ecological functions and critical landscape linkages. Simply stated, the evaluation of preservation will assess potential future loss. Riparian areas that are most pristine and make major contributions to watershed ecological functions will be designated as priority for preservation. Restoration specifically refers to actions taken to obtain a former state of a natural condition. Restoration potential will be determined by assessing the ecological integrity of the riparian area and assessing potential future gains in functional capacity, as measured by a likely increase in the ecological functions and critical landscape linkages. Sites that rank high for restoration potential may be highly degraded, but if restored, might re-establish important corridors or linkages between previously isolated habitats or provide a significant contribution to watershed ecological services.

The SWAMP assessment of regional priorities will take advantage of other data sources collected through other local and regional conservation and habitat protection planning efforts such as the Orange County Special Area Management Plan (SAMP) or the San Diego Multiple Species Conservation Program (MSCP). The SWAMP assessment will also take into account the proximity of existing protected areas such as National Forest land, nature reserves, or other protected lands in the decision-making process.

2. SAP recommendations for implementation of decision support tool project

The SAP recommends that the WRP undertake a series of activities to facilitate the adaptation and implementation of SWAMP in southern California. These activities are described below:

a. Review and comment on SWAMP assessment framework

The NOAA CSC is in the process of collaborating with the SAP and additional experts to develop the SWAMP assessment framework. The SAP asks that each of the WRP partner agencies as well as County Task Force members review and provide feedback on the each of the three modules (habitat, hydrology, and biogeochemistry) that comprise the SWAMP assessment framework. This work will be conducted through December 2002.

b. Development of data layers to support SWAMP assessment

A preliminary review of data sources in southern California has revealed major gaps in mapping of land cover and riparian zone vegetation needed to complete this analysis. Given the dramatic changes that have occurred in land use and cover in the past decade in this region, the date of existing land cover data sets (e.g. 1992 EPA National Land Cover Database) render them of minimal use for regional planning. The SAP recommends that the WRP aggressively pursue and support the development of regional data sets required to run SWAMP. This will involve the collection of existing data, as well as the acquisition and management of new data. The major types of data and the status of efforts to collect and/or acquire them, are given below:

- *Digital elevation model (DEM*): This detailed, digital topographic map used to determine riparian zone boundaries and drive assessment of physical components of the model. In the spring 2002, NOAA agreed to acquire IfSAR data for the WRP, and manage this data to develop a DEM model for the entire study area.

- *Land use/land cover*: Land use/land cover data will be used to characterize surrounding land uses, riparian vegetation, identify riparian zone boundaries and serve as proxy data set for riparian vegetation. In spring 2002, NOAA agreed to acquire new data through the Coastal Change Analysis Project (C-CAP). Data are anticipated in September 2003.

- *Riparian zone boundaries*: Riparian zone boundaries define the area in which SWAMP assessment will be carried out. The boundaries are delineated using a combination of data sources including a DEM model and land use/land cover data. While proposals have been submitted to federal sources (NOAA, GAP analysis program) to fund this work, support to develop this important data set is not confirmed. The SAP recommends that the WRP pursue additional funding sources to undertake the development of this data layer.

- *Riparian vegetation:* Currently, there is no regional GIS data layer describing riparian vegetation in southern California coastal watersheds. While land use/land cover data being developed by the NOAA C-CAP project can be used for some of the efforts, the resolution of this data source is 30 m. Many riparian corridors have riparian zones of widths less than 5 m. Therefore, the SAP recommends that the WRP work to develop a up-to-date map of riparian zone vegetation with a resolution of 2-5 m. This data layer will not only be used to in the SWAMP assessment, but also be incorporated into an inventory of wetlands and riparian resources in coastal watersheds (see Section IV).

- *Collection of existing data*: There are a number of existing GIS data layers that must be collected as a part of the SWAMP assessment. The County Task Force watershed coordinators, whose positions are funded by a Proposition 13 grant to Environment Now, will be assisting in the collection of the necessary data layers for the watersheds in each county.

All GIS data layers developed to support the SWAMP assessment will be made available online to the public through the WRP Information Station. They will also be used to support the development of a regional program to monitor freshwater wetlands and riparian resources in coastal watersheds.

CHAPTER IV. REGIONAL MONITORING OF WETLANDS AND RIPIARIAN ECOSYSTEMS

A. Need for Monitoring

By setting regional goals and adapting the quantifiable recovery objectives specified in this document, the WRP will have a set of clearly defined goals for the program and the elements of wetland structure and function that must be restored for ecosystem recovery. The next logical step is to implement a monitoring program that assesses baseline conditions, measures progress towards recovery, and evaluates the effect of anthropogenic stressors constraining recovery.

This program would have many other benefits. Among them, it would provide an integrated and cost-effective regional approach to addressing the management questions of WRP partners. It would streamline reporting of monitoring data, making them more accessible for routine scientific evaluation of restoration and management techniques. A recent study by a National Academy of Sciences Panel of the compensatory mitigation program found that the “no net loss goal” is not being met because of the lack of compliance monitoring and the success criteria do not assure establishment of wetland functions, particular those important in the landscape context (National Academy of Sciences 2001). Although the WRP is a non-regulatory program that is not involved with assessing compensatory mitigation, the development of a standardized methodology to evaluate wetland ecosystem structure and function within a landscape context could facilitate assessment of wetland regulatory and management policy including compensatory mitigation.

B. Recommended Approach

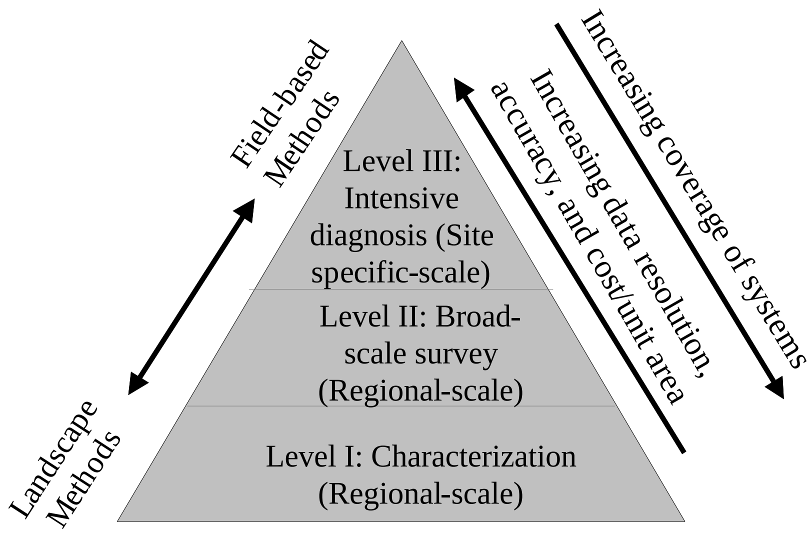
The SAP recommends that a regional wetlands monitoring program be established with three tiers of assessment. These three tiers address very different types of management questions (Fig. 8). Level I, the most basic kind of monitoring, is the characterization of the resource at the regional scale. The WRP Coastal Wetlands Inventory and the National Wetlands Inventory are both good examples of a Level I assessment. This type of monitoring addresses management questions about the extent of resource, without being able to address the condition of those resources. At this level, landscape or remote sensing methods are typically used to describe the resource. Use of landscape methods implies that assessment is conducted at a coarser resolution, but coverage of the wetland resources is region-wide.

Level II-type of monitoring goes beyond characterization to address management questions on resource condition and stressors on a regional scale. Using both remote-sensing and field based methods, assessments at this level also attempt to address management information needs on a regional scale. However, since the questions being addressed are more expensive to address, the assessments at this level are usually conducted by performing a survey on a random sample of wetland sites throughout the region. There are relatively few examples of this level of monitoring in southern California. Notable examples include the coordinated regional monitoring survey of the offshore environments of the Southern California Bight last conducted in 1998, the U.S. EPA Environmental Monitoring and Assessment Program (EMAP) study of subtidal habitats in

Southern California estuaries, and the California Dept. of Fish and Game annual survey of endangered coastal marsh birds.

Level III is the most intensive level of assessment, addressing detailed management questions of stressors and condition on a site-specific scale. It is perhaps the most commonly conducted form of monitoring in southern California wetlands. Relying mostly on field-based methods, the quality of information generated is much higher than in Levels I and II, but because of the expense, the information is collected at a few sites, and the information cannot be extrapolated to the region. Examples of Level III-type monitoring include data collected pre- and post-restoration, compensatory mitigation monitoring, assessments and species studies related to academic research, and monitoring performed as a part of management plans for federal and state lands.

Fig. 8. Components of a comprehensive regional wetlands monitoring program



The WRP and its partners are already conducting components of this idealized wetlands monitoring program. The Southern California Coastal Wetlands Inventory, prepared in 1996-1997 is a Level I assessment. WRP partners have also been conducting assessments at Level III, including monitoring associated with restoration projects, reserves, threatened and endangered species, and academic research. The level at which little work has been conducted is that of a regional survey (Level II).

An integrated regional monitoring program should address the specific information needs of the WRP agencies as well as the condition of the resource and the progress of recovery. It would also provide feedback on the success of restoration and management strategies, identify stressors common to wetland resources in the region, and provide information useful to set regional priorities for restoration and management. We recommend that this program be grounded in the elements of wetland ecosystem structure and function detailed in the quantifiable recovery objectives. A description of how quantifiable recovery objectives can be linked with a regional monitoring program is given in Section IV.C below. Specific SAP recommendations for the development and implementation of such a program follow in Section IV.D.

C. Linking Quantifiable Recovery Objectives with Monitoring

One of the principal motives in establishing quantifiable recovery objectives is to be able to draw direct links between recovery objectives and management actions. These links are established though monitoring to assess progress towards recovery objectives, using indicators that evaluate the success of management actions, the condition of the wetlands (natural and under restoration), and the stressors (e.g. contaminant runoff, population pressure) that may adversely impact the progress of recovery. It is in this manner that the quantifiable recovery objectives serve as the conceptual framework for a wetlands monitoring program

The development of the assessment framework and suite of indicators to assess progress towards the regional objectives and success of management actions must be specific for each of the major wetland classes (i.e. estuarine, marine, palustrine, lacustrine, riverine; Cowardin et al. 1979). However, to further clarify what we mean by indicators, and how they are used, we will illustrate several indicators that could be used to evaluate progress towards a recovery objective, using the estuarine wetland class as an example.

As noted earlier, there are five elements to assessing recovery of landscape elements of structure and function in estuarine wetlands. We will choose one of these, landscape hydrologic connectivity, to follow this thought process. There may be a number of restoration or management actions that could be taken to improve an estuarine wetland's landscape hydrologic connectivity. These would generally fall under the categories:

1. Restoring the connection to the ocean, either by reducing the number of wetlands with tide gates or water control structures;
2. Removing levees or dikes that hydrologically isolate wetlands from their freshwater sources (i.e. rivers) or upland buffers zones.

To evaluate the degree to which the management actions at a particular site have addressed this objective and recovery as a whole, assessment indicators can be selected. Indicators can vary – depending on the level of assessment (I-III) and the monitoring question (e.g. Table 3). They can vary in the expense and level of labor involved to monitor them. Thus, at a restoration project, long term monitoring of water levels may be required of the permitee to verify the restoration of hydrologic function, and relate this to the recovery of species and habitat diversity. On a regional level, we may choose to conduct a survey in which one site visit is made to evaluate the presence of tide gates or water control structures, or measure the percent attenuation of spring tides inside and outside the estuary. The indicators that are chosen are a function of the management questions that drive the monitoring, and the trade offs between cost of measuring them versus quality of information obtained.

Table 3. Demonstration of connection between recovery objective, management action, and indicator chosen to evaluate that action in estuarine wetlands.

Recovery Objective		Management Action	Sample Indicator	
			Site-specific	Regional Survey
Recover landscape elements	Recover landscape hydrologic connections	Increase number of wetlands with full tidal flushing	Occurrence of water control structure	% of wetlands with muted versus full tidal flushing
		Remove levees that hydrologically isolate wetlands from freshwater source or upland habitat	Monitor water exchange with river or frequency of flooding of upland habitat	Frequency distribution of wetlands by % of perimeter of wetland hydrological isolated by levees

D. SAP Recommendations for Wetlands Regional Monitoring Program

The SAP recommends that the WRP develop a comprehensive regional wetland monitoring program by implementing a level II-type of assessment, and by strengthening the coordination and developing synergy between all three tiers of monitoring. Specific recommendations are outlined below:

1. *Update present-day and historical inventories of southern California wetland ecosystems*: Currently, the present-day inventory covers only coastal wetlands and is not in a digital format. This inventory should be updated with new digital imagery and expanded to include freshwater wetlands and riparian areas in southern California coastal watersheds. Additional data layers should be added that describe, at minimum, the geologic and physiographic context in which these wetlands are located. This data set would be used as a baseline with which to document future changes in wetland resources. A historical inventory should also be created, using available data sources to document changes in wetland acreage by habitat type versus land use from time period of European settlement in the region. These data would also be utilized to document loss in acreage and diversity of habitat types from historic conditions, a source of important information in the establishment of regional habitat acreage goals (see Section III.A).

2. *Develop and implement a regional survey of wetland resource condition and stressors:* The WRP regional monitoring program should address the information needs of the WRP agencies, and assess the condition of the resource -- based on the elements of wetland ecosystem structure and function detailed in the quantifiable recovery objectives. Steps involved in developing this regional survey include assembling a project team representing WRP partner agencies, defining monitoring questions targeting specific management concerns, updating inventory to serve as a sample frame for site selection, and developing and verifying regional survey methodology. A proposal has been submitted to the EPA Section 104 program (Feb 2002) to update the wetland inventory and begin development of regional survey methodology.

3. *Develop a program to monitor the success of restoration projects:* The methodology developed for the regional survey of wetland resources can be adapted and used in the implementation of a functional assessment to evaluate the success of WRP restoration projects. Compatibility with the regional survey methodology assures that the data generated from these projects contribute to the regional assessment of wetland resource condition.

4. *Improve coordination of site-specific monitoring:* Monitoring conducted at the third tier, should utilize the standardized methodologies developed as part of the regional survey, and a common template for electronic reporting of data. Knowledge gained in restoration projects is often buried in monitoring reports or not completely disclosed by private sector consultants. Failed restoration strategies should be part of an iterative process that lead to better projects (Hackney 2000). Currently, data collected in restoration projects are not standardized in terms of the types of attributes monitored as well the format in which they are reported. The SAP recommends that a minimum set of monitoring requirements be adopted and that a standardized electronic format be required for reporting monitoring data. This data can then be made available to the scientists and the public to expand our understanding of the success and failures of specific restoration and management strategies.

5. *Develop administrative and financial infrastructure to support regional wetlands monitoring program*: The WRP should develop the administrative infrastructure and provide continuing support for implementation of regional monitoring program, including the analysis and dissemination of data.

CHAPTER V. SUMMARY OF SAP RECOMMENDATIONS

The SAP advocates the implementation of three initiatives to improve the regional planning of wetland ecosystem restoration and management. These are:

1. Establish quantifiable recovery objectives;
2. Develop decision support tools to aid in prioritizing preservation and restoration activities; and
3. Implement a regional monitoring program to measure the progress towards objectives.

The major attributes of wetland ecosystem structure and function important to recovery are identified in five quantifiable recovery objectives detailed in this document. The objectives and attributes identified should drive the assessment frameworks for a regional wetlands monitoring program, and for the decision support tools to prioritize the preservation and restoration activities of the WRP.

The SAP recommends that the WRP develop decision support tools to help prioritize the funding of preservation and restoration activities based on the ecological criteria outlined in the quantifiable recovery objectives. The SAP advocates that the WRP undertake two types of decision support projects: 1) establishment of habitat acreage goals, and 2) prioritization of riparian corridor preservation and restoration in coastal watersheds. Implementation of a habitat goals project depends on the development of data sources for this assessment. The SAP recommends that the WRP improve the historical and present-day inventories by habitat type, and catalog monitoring data that can be used to develop habitat requirements for wetland species.

The SAP also recommends that the WRP pursue the development of a decision support tool that will aid in identifying high priority riparian areas for preservation and restoration. This tool could be utilized by the WRP Managers group to guide the annual project selection, and by the WRP County Task Forces as a preliminary screening tool to develop priorities for the watershed management planning process. The WRP can support the implementation of the SWAMP decision support tool by: 1) reviewing SWAMP assessment framework currently under development, and 2) developing data layers to support the SWAMP assessment.

An integrated regional monitoring program can aid in assessing wetland resource extent and condition, guiding wetland restoration practices, managing watershed stressors, and verifying the effectiveness of wetland regulatory and management policy. Specific SAP recommendations for the implementation of this program include the need to 1) update present-day and historical wetland inventories, 2) develop a regional survey of resource condition and stressors, 3) develop a program to monitor success of WRP restoration projects, 4) improve coordination of project-specific monitoring, and 5) develop the administrative infrastructure to support a monitoring program.

GLOSSARY OF TERMS

Estuarine wetlands – Estuarine wetlands are subtidal and intertidal habitats that are semi-enclosed by land, have access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (Cowardin et al. 1979).

Habitat -- A collective term for the resources required by a species for its survival and reproduction -- the place where a species can be found. Habitat includes biological components such as the vegetation and fauna that serve as food sources and cover, and the geologic, hydrologic and geomorphic processes that serve as the foundation for the biotic interactions.

Habitat type – A term use to define the collective physical and biological resource (habitat) requirements shared by a group of species.

Hydric soil – Soil that is wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants

Hydrophytes – Any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content**.**

Lacustrine wetlands – Wetlands which have the following characteristics: 1) situated in a topographic depression or a dammed river channel, 2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30% areal coverage, and 3) total area exceeds 8 ha (20 acres; Cowardin et al. 1979)

Marine wetlands – Subtidal and intertidal wetlands found on the oceanic continental shelf and high-energy coastline. Habitats are exposed to the waves and currents of the open ocean and the water regimes are determined primarily by the ebb and flow tides (Cowardin et al. 1979).

Mesophyte, mesophytic – Any plant growing where moisture and aeration conditions lie between extreme (plants typically found in habitats with average moisture conditions, not usually dry or wet).

Riverine wetlands – Wetlands contained within a channel system with water containing salinity of less than 0.5 part per thousands. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water (Cowardin et al. 1979).

Palustrine wetlands – All non-tidal wetlands dominated by trees, shrubs, lichens, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. The palustrine class also include non-vegetated wetlands, but with all of the following characteristics: 1) area less than 8 ha (20 acres), 2) active wave-formed or bedrock shoreline features lacking, 3) water depth in the deepest part of the basin less than 2 m, and 4) salinity less than 0.5 ppt (Cowardin et al. 1979).

Preservation -- *Preservation* includes the acquisition of fee title or conservation easements in wetlands, riparian areas, and associated upland habitats that are presently in private ownership and therefore not subject to conservation guarantees.

Restoration -- *Restoration* specifically refers to actions taken to obtain a former state of a natural condition. In the context of this paper, is the re-creation and enhancement of wetland habitat.

Riparian ecosystem – Using the US EPA definition, this refers to a **"**vegetated ecosystem along a waterbody through which energy, materials, and water pass. Riparian ecosystems characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not have in all cases the characteristics necessary for them to be also classified as wetlands" (EPA 2001).

Riparian area – For the purposes of this document, riparian areas or zones refer to the transitional areas upland of wetlands that either 1) support predominantly mesophytic vegetation (trees, scrub and herbaceous cover) or 2) have soil that is predominantly non-hydric. Riparian areas are not just unique to the upland transition zones of riverine wetlands (in linear corridors), but can also be found in adjacent to palustrine, lacustrine and estuarine wetlands.

Wetland – Using the U.S. Fish and Wildlife definition, wetlands are "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin et al. 1979).

Wetland Ecosystem -- For the purposes of this document, "wetland ecosystem" includes both wetlands and the transitional and adjacent upland habitats.

Wetland Recovery – As used in this document, the "recovery" refers to both the response by the wetland ecosystem to restoration and enhancement activities, as well as a demonstrated resilience of the wetland ecosystem to the natural and anthropogenic stressors

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